

Battery System Requirements and Challenges for Commercially Successful Plug-In Hybrid Electric Vehicles

Plug-In Hybrid Electric Vehicles
AQMD Forum and Technical Roundtable

Johnson Controls – **SAFT** *Advanced Power Solutions*

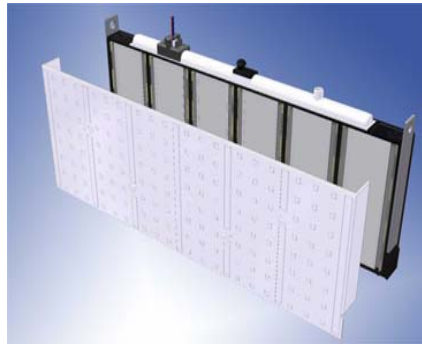
July 12, 2006

Michael Andrew

Overview

- Johnson Controls – SAFT Advanced Power Solutions background
- Commercialization challenges – the battery manufacturer's perspective
- PHEV definition?
- Summary and recommendations

Johnson Controls - **SAFT** *Advanced Power Solutions* Overview



Johnson Controls Power Solutions

- The world's leading global automotive lead-acid battery supplier
- 2005 sales \$2.9 billion
- Global capacity of over 110 million batteries
- Multi-million dollar advanced R & D Centers in 5 countries
- Advanced battery technologies for advanced vehicle systems
- Electronics integration capabilities

SAFT

- Major supplier of battery systems to transportation and military
- Expertise in NiMH and Li-Ion battery technologies
- **Joint Venture formed in January 2006 with Saft**
- JCS Advanced Power Solutions is the exclusive entity for HEV/EV advanced batteries for Johnson Controls and Saft

Key Attributes of a Plug-In Hybrid Electric Vehicle (PHEV)

- The PHEV is functionally equivalent to a conventional HEV while driving.
- The battery in a PHEV is capable of being recharged by the grid, typically overnight, in addition to accepting regenerative braking electrical power.
- The power train control strategy could favor electrical power over internal combustion engine power early in the drive cycle such that stored electricity is the preferred energy source while the battery is near full charge.
However.....
-**PHEV's can offer efficiency and petroleum fuel displacement advantages even without offering electric-only operating range.**
- PHEVs enable significant reductions in tail pipe emissions

For the Battery Manufacturer, the Transition from HEVs to PHEVs is Not Simply a Scale-up Opportunity

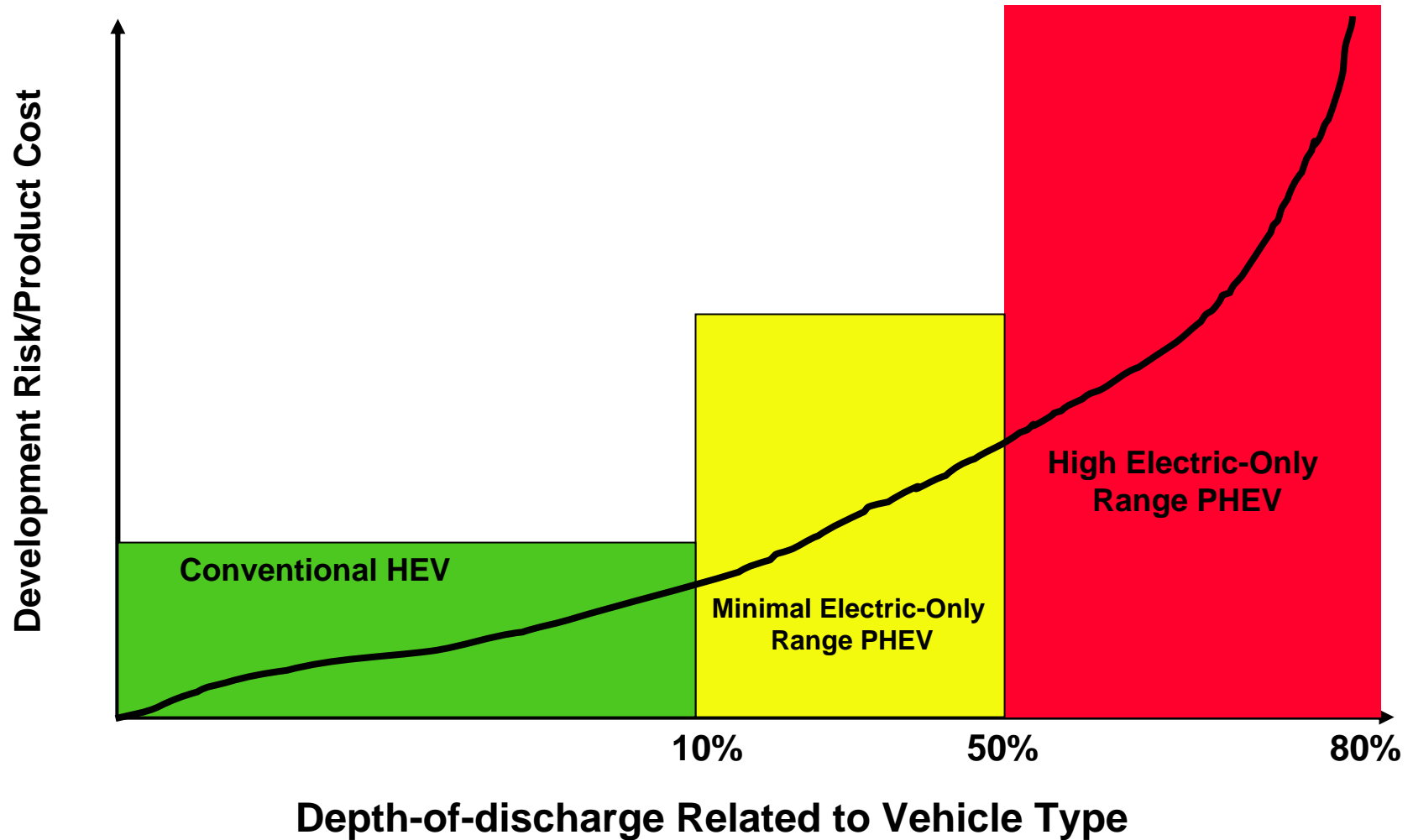
Business Case Challenges are Driven by the Following Factors:

Battery System Requirement	System Type		Development Risk	Cost Impact
	HEV	PHEV		
System voltage	200-300 V	200-300 V		Neutral
Cell Capacity	4 - 10 Ahs	40+ Ah		High
HVAC System	Air	Possibly liquid-cooled		Moderate
Depth of discharge	2-10%	2-80%		High
Battery management subsystem complexity	x	xx		Moderate
Design for abuse tolerance	x	xx		High
Manufacturing Investment	x	xxx		High
Warranty structure complexity	x	xxx		Moderate*
Calendar Life	10+ yrs.	10+ yrs.		Moderate
Cycle Life	300,000	TBD		High

* High if battery is discharged onto grid during peak demand periods

Cycle Life is a Key Challenge as Electrode Utilization (d.o.d.) Increases

Battery Life is a function of “typical d.o.d.” and the number of cycles



Dominant Cost Drivers Need to Be Addressed

- 
- Net Energy Content
 - “Typical” traction energy
 - Vehicle Duty Profile and Usage Patterns
 - Depth of discharge
 - Accumulated cycles
 - Thermal Management

Gross Energy Content

- P/E Ratio and Electrode Processing
 - Active material particle size and cold weather performance
 - Electrode length and thickness
- Materials Development
 - Improve d.o.d./life functionality
- Battery Management, Thermal Management

Summary and Recommendations

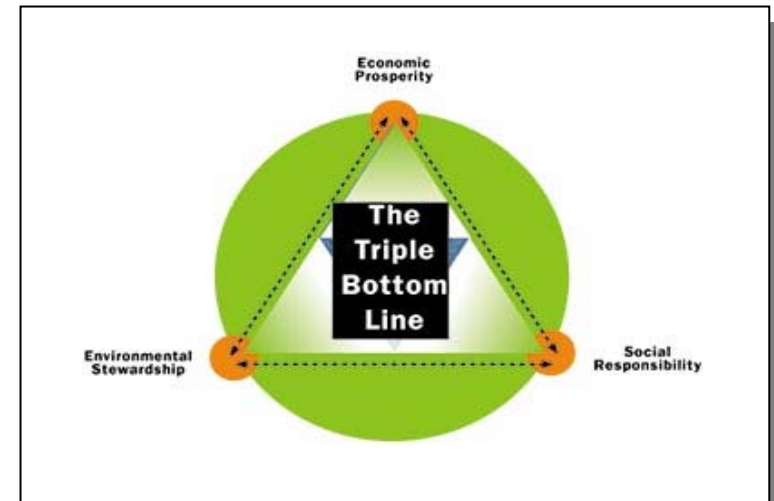
- JCS believes the potential for PHEVs to improve the energy/environmental health of the United States and the world is real and should be further explored.
- We support the Advanced Energy Initiative proposed by President George W. Bush.
- We applaud the work being done by organizations like DOE, EPRI and AQMD to better understand the cost/benefit trade-offs for PHEVs.
- On-going discussions with all stakeholders should be accelerated. This is an excellent opportunity for the United States to assert both environmental and technological leadership.
- We support DOE's plan to invest in system design modeling and trade-off analyses in advance of coordinating with USABC on component and system development contracts

Johnson Controls is Committed to its Leadership Role in Environmental Stewardship and Social Responsibility...

- Founding member, Green Buildings Council and developer of LEED (Leadership in Energy and Environmental Design), the certification standard for green buildings
- 2004 World Environment Center Gold Medal for International Sustainable Development
- U.S. DOE Energy Star partner
- Member: minority business “Billion-Dollar Roundtable”
- Dow Jones Sustainability Index
- Igniting Creative Energy Contest for K-12 students
- USABC/DOE hybrid battery partnership



2005 Johnson Controls/USEA Energy Forum, Washington, DC
Johnson Controls Chairman and CEO John Barth welcoming President George Bush



Johnson Controls - Saft

Advanced Power Solutions

Thank You!

© Copyright 2006 Johnson Controls – SAFT Advanced Power Solutions LLC. All rights reserved.
Certain subject matter shown in the document may be patent pending.